Specimina Ichnographica:

OR, A BRIEF

NARRATIVE

Of ſeveral new

INVENTIONS,

AND

EXPERIMENTS;

PARTICULARLY,

The Navigating a Ship in a Calm,
The Improvement of the Engine to raiſe Water by Fire,
A new Method of drying Malt, &c.

For all which his MAJESTY has lately been moſt graciouſly pleas'd to grant his *Letters Patent* to

JOHN ALLEN, M.D.

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BRITISH MUSEUM

TO THE

KING'S moſt Excellent Majeſty,

THESE

DISQUISITIONS

ARE

Moſt humbly Dedicated

BY

His MAJESTY'S

Moſt Dutiful,

and moſt Obedient

Subject and Servant,

JOHN ALLEN.

Specimina Ichnographica.

Dissertation I.

A new Invention for Heating and Boiling Water or other Liquors, with far leſs Expence of Fuel, than by the common Methods now in Uſe.

Art. 1. THE common Method of boiling Water and other Liquors (ſince the Invention of ſetting Furnaces in Brick-work) is by the Application of Fire under the Bottom, and round the Sides of the Furnace or Boiler, wherein the Water is to be boiled. In this Way (notwithſtanding how much ſoever it may exceed the boiling of Water in a Kettle over an open Fire) it is evident, that well nigh half of the Heat or Effect of the Fire, is employ'd in heating the Walls of the Fire-place, and conſequently ſo much of it is in great meaſure loſt. Beſides, in the beſt contrived Furnaces that ever I ſaw, the Current of Flame and Heat, after having fetch'd one ſingle Compaſs by a Flue round the Furnace, makes its Exit preſently into the Tunnel, where the greateſt Force of the Heat is immediately ſent up into the Air, and any farther Benefit and Advantage of it entirely loſt.

Art. 2. Moreover, when there is a great Quantity of Water to be heated, as in large Boilers containing 30 or 40 Hogſheads, the Body or Bulk of it is ſo large, that the Contact of the Fire on the Outſide of the Boiler muſt be every where at the Diſtance of 4 or 5 Foot from ſome Parts of the Water, which renders the Operation exceedingly ſlow before it boils, and alſo is the Occaſion that it requires much more Fuel to keep it boiling, than if Matters were otherwiſe order'd, as will be ſeen by and by.

Art. 3. It will be needleſs to ſet forth here the various Experiments I have made Uſe of, with Relation to the Article of ſaving the Expence of Fuel in boiling Water; ſince it will be ſufficient if I deſcribe the new Method I propoſe, and explain the Conſtruction of a large Boiler; for inſtance, one about the Size of that employ'd at *York-Buildings*, for working the famous Engine for raiſing Water by Fire, which is the nobleſt Invention that any Age has produced, and is of far more extenſive Uſe than has hitherto been thought of, and eſpecially it will be ſo, when it has received the Improvement of being wrought with one half of the Fuel now conſumed.

Art. 4. In the Method I am ſpeaking of, the Fire is not to be made on the Outſide of the Boiler, as in the uſual Way, but in the Center or Midſt of the Water to be boil'd, in a Furnace of Copper, Braſs or Iron, &c. of a peculiar Form and Figure; and the Water to be contain'd *undequaque* on the Outſides of it, in a Veſſel made of Wood, Lead, or any other Material that will hold Water, by which Means the whole Force and Energy of the Fire will be imploy'd ſolely in heating the Water, the Fire here is cloſely confin'd, and the Heat not ſo ſoon diſcharg'd in the open Air, the Surface of Contact of the Fire againſt the Water will be larger, the Diſtances the Fire is to penetrate much leſs, the Superficies of the Water for emitting Steams greater; and conſequently far leſs Expence of Fuel will be required, &c.

A Deſcription of the new Boiler, Fig. 1.

Art. 5. The whole Figure is a Section of it lengthways through the Middle. ABC is the Copper, Braſs or Iron Veſſel, or Fire-place, included in a large external Veſſel D E F G, two thirds full of Water, ſupported in its proper Situation by Iron Bars from the Bottom Plank EG, and firmly ſcrew'd down to the ſaid Plank by means of a Planchet or Border *aa* on the Outſide, round the Part, where the Fire is to be made on the Grate H, in ſuch manner that no Water may iſſue out.

This Copper Veſſel, at the Place where the Fire is made, is to be in Breadth from A to I about 21 Inches, and in Height about 3 Foot from H to K, and in Breadth the other Way on the Flat (not viſible in this Figure) 4 Foot: and then from I to B, where it turns up, it is to be of one uniform Depth and Breadth, *viz.* a Foot deep and 4 Foot broad. Laſtly, from B to C the Tunnel where the Smoak is diſcharged, it may be made tapering from 4 Foot to 2 Foot, or a Foot and half, and from 12 Inches to 10 or 9, as will beſt ſerve the Occaſion, and carried up by a Tin Shaft to any Height. So much for the Copper or Fire-place.

The large Veſſel D E F G, containing the boiling Water, is to be made after the following Manner: The Top and Bottom each to conſiſt of three good ſubſtantial Planks 5 or 6 Inches thick, 2 Foot broad, and 14 Foot long, well fitted together, and the Joints or Seams calked within and without with Oakham. This Top and Bottom are to be kept aſunder at their proper Diſtance with a Frame of Wood or Iron Bars placed in the Inſide, *viz.* at the End D E at 7 Foot Diſtance, and at the other End F G 5 Foot. This being done, the Sides are to be made of good ſubſtantial Sheet Lead, firmly nail'd all round to the Edges of the Top and Bottom Plank; and this would complete it, was it not, that there will be a Neceſſity to take it abroad ſometimes to mend the Copper within, when defective; therefore it muſt be made to take aſunder in the Middle, which may be thus contrived. The

Lead muſt be diſpoſed of in two Sheets, one of them nail'd to the upper Plank, and the other to the bottom one, as before mentioned; and at the Middle, where they are to meet, they muſt be allow'd broad enough to turn off ſquare outwards, about 3 Fingers Breadth, ſo that they may lie flat one on the other, and being thus placed, thin Plates of Iron clap'd on each Side, and ſcrew'd together with Screw-Pins thro' Lead and all, will ſo pinch the Foldings together, that the Joint will be ſecured from leaking; or if this Method ſhould not be thought ſufficient, the Edges may be ſolder'd together, the Expence being not very great. If the Sides of this Boiler, being of Lead, ſhould not be ſuppoſed to be ſtrong enough to ſuſtain the Weight of the Water within, and the Force of the Steam, *&c.* it will be very eaſy to ſtrengthen the Outſide with a Frame of Timber-work ſcrew'd together, that may be taken abroad at Pleaſure. And thus this Boiler may be open'd at any Time to repair the Copper within, which alſo may be taken out without much Trouble, only by unſcrewing it from the Bottom Plank at the Grate. Laſtly, a Caſe of Boards may be fitted all round the Boiler, fill'd with Sand to keep in the Heat, the Sand may be perhaps 8 or 9 Inches thick or more, as will be found beſt to anſwer the End.

Art. 6. The better to diſcover the Preference of this Boiler to the common Furnaces, it will not be amiſs to make a Compariſon between them. The Capacity of the Boiler of the Engine to raiſe Water by

Fire at *York-Buildings*, is nearly the ſame with this here deſcribed. I ſuppoſe the Diameter of that Furnace to be about 8 Foot and a half, and its Depth about 8 Foot; if ſo, its Contents will be about 453 cubical Feet, which is about 53 Hogſheads, after the Rate of 8 Foot and a half to the Hogſhead, which is a little more than Wine Meaſure; be that as it will, to reckon by cubical Feet will be the moſt commodious for the preſent Calculation.

ART. 7. The Compariſon.

The Boiler at York-Buildings.	*The New Boiler.*
Suppoſe we then, the total Capacity of the Boiler at *York-Buildings* to be in cubical Feet 453.	The Dimenſions here being 14 Foot long, 6 broad, and, at a Medium, 5 deep, the whole Cavity would contain 504 cubical Feet; out of which the Space the Copper or Fire-place takes up (about 50 Foot) being deducted, what remains will be in cubical Feet 454.
Two thirds of this Boiler to be filled with Water; and one third for the Reception of Steam.	The ſame in this.
The Contact of the Fire againſt this Boiler may be ſuppoſed to be all over the Bottom, and about 18 Inches up the Sides, which is in ſquare Feet about 95.	The Contact of the Fire in this, reckoning the leaſt of it, is more than 10 Foot *per* 12, 120, exceeding the other 25 Foot. The Contact of the Fire, I ſay, is in ſuperficial ſquare Feet 120.
Water kept boiling (as I have experienced with great Exactneſs) evaporates after the Rate of an Inch and half in Depth per *Hour:*	
Therefore	The

Therefore the larger the Surface, cæteris paribus, *the greater the Evaporation or Production of Steam,*	
The Superficies of the Water in this Boiler is in ſquare Feet 56.71.	The Superficies of the Water in this Boiler (the Dimenſions being 14 *per* 6) is in cubical Feet 84.
The Water therefore evaporated in an Hour in this will be in cubical Feet 7, about 52 Gallons.	The Water evaporated in this therefore will be one third more than in the *York-Buildings* Boiler, which will conſequently generate one third more Steam, *viz.* every Hour in cubical Feet 10.5 about 78 Gallons.
The Water in this Boiler lies together in a vaſt bulky Body, 8 or 9 Foot Diameter, and about 5 or 6 Foot deep; ſo that the Fire on the Outſide does not reach the middle and upper Part of it within, by 4 or 5 Foot.	In the new Boiler (which is a very conſiderable Advantage in this Invention) the Fire is hardly any where much more than at a Foot's Diſtance from any Part of the Water, as is apparent from the Conſtruction of it.
Laſtly, in this, as in all other common Furnaces, the Force of the Fire is hurried away with great Impetuoſity from the Fire-place, through the Flues up the Tunnel, without imparting its greateſt Efficacy to the Water it is to heat.	In the new Boiler the Fire is ſo contrived, that it burns in a Reverberatory Furnace, which affords the ſtrongeſt Heat that culinary Fire is capable of producing by any Art we know of, and that Heat is retained and improved to the utmoſt, before it is diſmiſſed at the Tunnel.

The Compariſon between theſe two Boilers here ſet forth, being conſidered, and the ſeveral Advantages of the one above the other duly weighed, will without doubt ſufficiently recommend this new Method to be put in Practice, and therefore it will be needleſs to add any thing more in Vindication of it.

ART. 8. However there may be contrived another Sort of Boiler, the Conſtruction of which is ſomewhat different from this now deſcribed, tho' in the main deduced from the ſame Principles; but I cannot ſay whether much preferable to it or not, having not made Trial of it; it is as follows:

The external or containing Veſſel here is a Cylinder, Fig. 2. whoſe Diameter is to be 9 Foot, and its Altitude 8 Foot and a half, the Top and Bottom of firm Plank, and the Sides of Lead, hooped with Iron Hoops, or perhaps it may be all of Wood, if ſo large a Caſk can be made.

From the Fire-place (of the ſame Dimenſions with the other) is to be continued a large Copper-worm about 15 Inches Diameter, and about 40 Foot in Length, as is viſible in the Figure. By which Contrivance the Flame, heated Air, and Smoak are retained more than three Times as long as in the other, which is a very ſingular Privilege and Advantage in this Form; the Contact of the Copper againſt the Water to be heated is far more extenſive, than in the other; all other Things relating to it are pretty much the ſame. If this ſhould not be found to have Draught enough of Air barely by the Admiſſion of it at the Grate, a large Pair of Bellows may be made uſe of to force the Fire, as may be found neceſſary.

ART. 9. It is a Thing well known, that in boiling of Water in a cylindrical Veſſel over a Fire, there is a conſtant Flux of the bottom Part of the Water, as it heats, to the top; and alſo a reciprocal Flux of that at the Top, which is colder, down towards the Bottom, occaſioned from the Difference of the ſpecifick Gravity in the Parts of the Water at the Top and Bottom of the Boiler, the Heat communicating itſelf to that Part of it, which is next to the Fire, rarifies it, and makes it lighter, and cauſes it to aſcend; and conſequently that, which is colder, deſcends.

Art. 10. From this Theory, which is Matter of Fact, it is evident that this Boiler is contrived very advantageouſly, for that the upper Part of the Water receiveth the ſtrongeſt Heat, and boils moſt furiouſly, whilſt the lower Part has alſo a moderate Share of the Benefit of the Fire, ſo as to prepare it to aſcend, as Occaſion requires, to anſwer the Evaporation; for which Reaſon I ſhould adviſe the Supply of freſh Water to be made at the Bottom of the Boiler, not at the Top, as it is uſually done in the Fire-Engine from the large Cylinder or Steam-Barrel; I mean, that the warm Water deſcending from thence ſhould be conveyed into the Boiler near the Bottom of it, not at the Top; becauſe the coming of it in there damps the boiling, and hinders the Aſcent of the Steam.

Art. 11. This Boiler would exceed the other in point of ſaving Fuel; but then the Conſtruction of it may be look'd upon ſomewhat more difficult, and the repairing and amending of it, when Need requires, perhaps not quite ſo eaſy; tho' even this is not to be look'd upon as impracticable.

Art. 12. It is now more than 30 Years ſince the Engine for raiſing Water by Fire was at firſt invented by the famous Captain *Savery*, and upwards of 20 Years that it received its great Improvement by my good Friend the ever-memorable Mr. *Newcomen*, whoſe Death I very much regret; and that it has not been more frequently made uſe of, and employed alſo to other Purpoſes, as well as almoſt ſolely the draining of Coal-mines, ſeems to be owing to the great Expence of Coals that is required for the working of it, it being at preſent ſo very expenſive on that Account in ſome Parts of *England*, eſpecially where Coals are at an exceſſive Price, that in many Copper and Lead-Mines it cannot be ſet up.

Art. 13. For the working the Engine at *York-Buildings*, the Article of Coals is at leaſt 1000 Pounds a Year, and proportionably as much in all others, where Coals are as dear as they are in *London*, according to the Largeneſs of the Engine. Now if this Engine can be wrought at half the Expence of Coals, or even at two Thirds of the Expence, there will be great Encouragement, not only for the ſetting it up in many Places, where at the preſent it cannot be afforded, but alſo of applying it to many other Uſes in Mill-Work, and particularly for draining large Levels of low Lands, to which Purpoſe I greatly admire that it has never been as yet applied, when a whole River might be lifted with it 4 or 5 Foot high or more, as Occaſion ſhould require.

Art. 14. One conſiderable Advantage of this new Boiler, that has not hitherto been mention'd, is, that it is capable of being removed and ſhifted with great Eaſe from one Place to another, which cannot be ſo readily done in Furnaces that are ſet in Brick-work. By this means it may without great Trouble be adapted to this or that Shaft of a Mine, as Occaſion may require. It may alſo be put on Board to navigate a Ship, as will be ſhewn in the Sequel of this Tract, which the Fire-Engine now in Uſe is altogether incapable of, on account of its Brick-work Furnace.

DISSERTATION II.

New Inventions for the Application of Powers (never before made uſe of for ſuch Purpoſes) to give Motion to Engines, whereby a Ship may be navigated in a Calm, and ſome other great Works perform'd, where much Force is required.

Art. 1. THE ancient *Greeks* and *Romans*, for ought we read in Hiſtory, contented themſelves with giving their Ships a Motion in calm Weather by rowing them with Oars, much after the ſame Manner as the Galleys are rowed now-a-days. Several Attempts have been made in our modern Times to navigate a Ship in a Calm, after a more expeditious Manner, and in a leſs laborious Way, than can be effected by the Means of common Oars; but theſe Attempts have hitherto all of 'em proved unſucceſsful, their Contrivances having been (by all that I could hear or learn of 'em) by ſome kind of Machinery working without the Ship, having a Motion communicated to them from within from the Capſtan or otherwiſe, ſomething analogous to Oars, Paddles, or by the Revolution of Wheels, or the like, which have ever been found incommodious, and conſequently not practicable.

Art. 2. The Method, that I propoſe for navigating a Ship, is altogether of another Nature, and very different from any Thing that has been ever yet attempted, no Part of its Machinery or *Apparatus* being without the Ship. In ſhort, the Principle of giving Motion to the Ship, in my Way, is by forcing Water or ſome other Fluid through the Stern or hinder part of it into the Sea by a proper Engine or Engines placed within the Ship for that Purpoſe.

Art. 3. This is an Operation conſentaneous to Nature, agreeable to what the Author of it has ſhewn us in the Swimming of Fiſhes, who proceed in their progreſſive Motion, not by any Vibration of their Fins, as Oars, but by Protruſion with their Tails. So likewiſe Ducks and other Water Fowls ſwim forward by paddling with their Feet behind their Bodies. Nor is it diſſonant to ſome Productions of Art; witneſs the Sky-rockets aſcending in the Air by Virtue of a Stream of fired Gun-powder forceably burſting out at the lower End of it, and the Recoiling of a Canon when it is fired off, *&c.*

Art. 4. I got a Tin Machine, or Sort of Boat, to be made 11 Inches long, 5 Inches broad, and about 6 deep. I put it into a Veſſel of ſtagnant Water, and loaded it in ſuch manner, that it ſunk in the Water exactly 3 Inches and three quarters in Depth, and in ſuch Caſe 18.75 ſquare Inches would be the Surface of it preſenting to the Water, which we call the Surface of Reſiſtance immerſed in the Water, which Surface of 18.75 Inches, was equal to 300 times the Aperture in the Pipe or Tube of a quarter of an Inch ſquare, by and by to be mentioned. In this Tin-Boat was placed a cylindrical Veſſel 6 Inches high, and almoſt 3 Inches Diameter filled with Water, and at the Bottom of it in a horizontal Poſition, was a ſmall Pipe or Tube a quarter of an Inch ſquare, carried quite through the Stern of the Boat, about an Inch and half under the Surface of the Water in which the Boat floated, where it had its Aperture of a quarter of an Inch ſquare. Things being thus prepared, I ſtopt the Aperture, at the End of the Tube, under Water, with my Finger; and then, when the Boat was in a ſteady Poſition, and the Water calm, I gently drew it away, and leaving the Boat at Liberty, the Water beginning to run out at the End of the Tube, gave Motion to it as I expected; which Motion, as nearly as I could obſerve upon many Trials, was 3 Foot in 10 or 11 Seconds of Time, which is after the Rate of 1056 in an Hour, or one fifth of a Mile. The Column of Water being 6 Inches high, we may ſuppoſe the Preſſure of it at a Medium to be equal to 3 Inches in Height. The Motion of the Boat at the firſt was very ſlow, but increaſing gradually towards the laſt it was more ſwift, and could it have been continued longer, it would doubtleſs have acquired ſtill a ſomewhat greater Celerity.

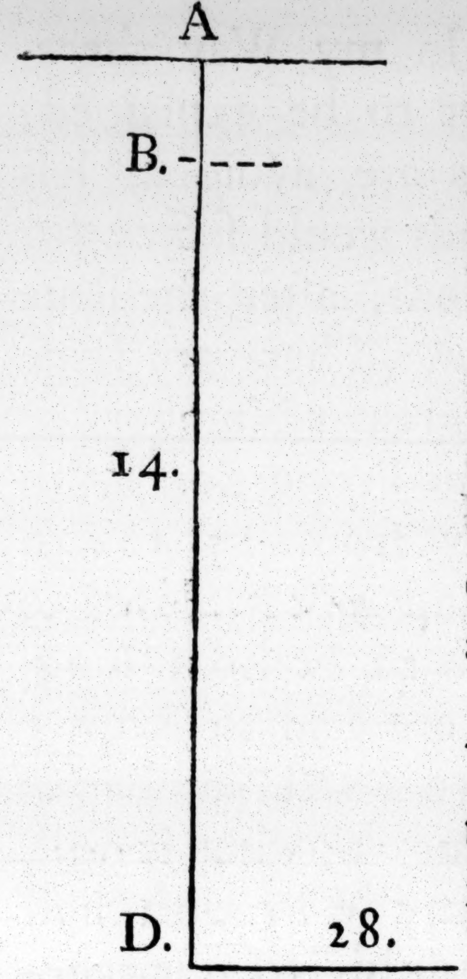
ART. 5. Let us in this Experiment ſuppoſe the reſiſting Surface to be augmented to 500 ſquare Feet, which is much about the Size of a croſs Section at the main Breadth of a 70 Gun Ship; then in proportion the Diameter of the Aperture of the Tube muſt be enlarged to about 20 Inches ſquare; then it is plain, that the Preſſure of a Column of Water of 20 Inches ſquare and 3 Inches high, would move the Ship after the Rate of 1056 Feet, or one fifth of a Mile in an Hour. The Weight of a Column of Water 20 Inches ſquare and 3 Inches high, will be found to be 25 Pound and .3328 in Decimals, at the Rate of a cubical Foot of Water (being Salt-water) weighing 64 Pound.

ART. 6. It has been abundantly demonſtrated, or at leaſt preſumed to have been demonſtrated, that the Reſiſtance of Fluids is as the Squares of the Velocities of ſolid Bodies moving in them, and the moving Powers are always equal to the Reſiſtances. Hence in the Caſe before us, as the Square of the Velocity of one fifth of a Mile in a given Time, *viz.* an Hour, is to the Square of the Velocity of 2 Miles; ſo is 25.3328 to a fourth proportional, which by working will be found to be 2533.2 &c. Pound Weight, which is equal to the Force required to navigate a Ship, whoſe Surface of Reſiſtance contains 500 Foot, at the Rate of two Mile an Hour, according to this Way of Reckoning. This, how random a Computation ſoever it may ſeem to be, will notwithſtanding be found not very diſtant from other more accurate Calculations, or from the Truth itſelf in Fact.

ART. 7. Some Things very well worth remarking to the Purpoſe in Hand, may be obſerved from the Rowing of the Galleys in the *Mediterranean* Sea. A Galley, whoſe Surface at a croſs Section at the main Breadth preſenting to the Water is 80 Foot, having 52 Oars, and 3 Men at an Oar, (156 Men) proceeds ordinarily in a Calm at the Rate of about 3 Mile and two thirds in an Hour. At that Rate of Rowing, the Weight of Water againſt the Galley is 2240 Pounds, according to M. *de la Hire*, Memoir des Scien. *Anno* 1702. *p.* 370. allowing it ſo (tho' it is no more than 1606) that Weight being equally divided among the 156 Men, each Rower impels towards navigating it no more than 14 Pound and 6 Ounces or thereabouts, which they unitedly contribute to give it that Motion.

But then it is to be conſidered, that at leaſt two thirds of their Force is loſt in wielding the Oars being 36 Foot long, which muſt be moved upwards and downwards, as well as backwards and forwards; and in giving it this laſt Motion the Rowers are obliged to run backwards and forwards, he that is the fartheſt from the *Fulcrum* no leſs than 6 Foot, and the reſt proportionably; add to this, that they ſometimes meet with Oppoſition of Water in fetching their Stroke, and ſometimes quite miſs their Stroke; beſides they wreſt the Galley from Side to Side, and diſturb its direct Motion, one Side of the Rowers happening almoſt always to out-row, or pull ſtronger than the other, which is unavoidable; this makes the Galley move in a crooked Line from Side to Side; but this you will ſay is to be help'd by the Steerage, right; but then ſo much as it is rectified by the Rudder, ſo much of the Motion is abated and retarded. There is alſo yet another Thing, which in ſome meaſure impedes the progreſſive Motion, which is the Dancing of the Galley upwards and downwards, occaſioned by the lifting up and plunging down the Oars in the Sea. It is farther to be obſerved, that they ſtrike no more than 24 Strokes in a Minute, and one third of that Time only is applicable to give Motion to the Galley, the reſt being imployed in weilding the Oars, *&c.* as before noted. By Reaſon of theſe Impediments it cannot be ſuppoſed, that more than one third of the Rower's Strength exerts itſelf in forwarding the Galley. In my Way therefore of Navigating, herein after to be explained, wherein all theſe Inconveniencies are avoided, leſs than half of the Number of Hands would ſuffice for Rowing a Galley of that Dimenſions, after the Rate of 3 Miles and two thirds an Hour. There are ſome Galleys that are larger, and have greater Numbers of Hands on Board, but then the ſame Proportion holds good in all. They have uſually from 25 to 30 Benches of Oars on each Side, and 4 or 5 Slaves to each Bench; they are from 20 to 22 Fathom long, 3 broad, and 1 deep; and they are ſaid to Row 5 Miles an Hour, but then they have a vaſt Number of Hands. Let their Rate of Rowing be what it will, the ſame is to be performed in my Way with half the Number of Men, which certainly is Incouragement enough for thoſe that make Uſe of Galleys, to put this Method in Practice, whatſoever the Wiſdom of this Nation may think fit to do.

ART. 8. *Philoſophical Tranſactions*, No 169. A cubical Foot of Pump Water, by Experiment is found to weigh 62 Pound and 8 Ounces; but Salt-water may weigh about a twenty-ninth or a twenty-eighth more than common Water; which Allowance being made, a cubical Foot of Sea Water at the moſt can weigh no more than 64 Pound, which I make the Standard in my future Calculations.



Art. 9. Water falling from a Reſervoir 14 Foot high, from A to D, acquires the Velocity of 28 Foot in a Second, as has been found by very nice Experiments.

From whence a general Rule for Calculation in all Caſes may be eſtabliſhed, (Reſiſtances of Fluids being as the Squares of the Velocities of Bodies moving in them) as thus:

As 784 (the Square of 28, the Velocity in D) is to the Square of the Velocity in B, (which is to be found by Experiment, it being the Velocity of the Current, or the Velocity you would have the Ship to ſail at in a Second of Time, or the Height of the Reſervoir from A to B, which are all the ſame Thing; for Example, ſuppoſing the Current to move after the Rate of one Mile an Hour, *viz.* 5280 Foot, then it would move 1.4666 *&c.* in a Second, the Square of which is, 2.1508.) ſo is A D, 14 to a fourth Term, which fourth Term is the Length of the Line from A to B, and is to be multiplied by 64, the Pounds in a cubical Foot of Water, *(vid. Art. præced.)* and this Rule will hold univerſally. See the Operation following;

2.1508

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       2.1508
         14.
      ————————
       86032
      21508
      —————
784.)30.1112 (.0384—
     23.52       64.
    ——————   ——————
      6.591    1536
      6 272   2304
      —————  ——————
       .3192  2.4576 = to the Weight of Water againſt one
       .3136             Foot, at the rate of one Mile an
      ——————             Hour.
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For AB, the Height of the Reſervoir being determined from the given Celerity, and the Proportions being as above mentioned, it will be eaſy to diſcover the Reſiſtance of the Water in all Caſes whatſoever, and the Powers able to overcome it in any ſingle Foot of Water; and from thence the croſs Section of a Ship, which is the Surface of Reſiſtance, being given in ſquare Feet, the Power to navigate it in ſtill Water may be known by multiplying the Weight of Reſiſtance of that ſquare Foot, into the Number of ſquare Feet contained in the Ship's Surface of Reſiſtance. So alſo the Force required to navigate a Ship or Boat againſt any determined Current may be found out, if we add the Celerity of the Current to the Reſiſtance of dead Water, and proceed in the Manner ſpoken of.

After this Manner may be found the Force required to navigate a Ship of any Burthen, after the Rate of 1, 2, 3, 4, *&c.* Miles an Hour, by the ſame Method of Proceeding.

Art. 10. A 70 Gun Ship may be about 38 Foot Beam, and may draw 16 Foot Water, not including the Keel; a Section then at the main Breadth will contain about 500 Foot, which is the Surface of Reſiſtance. And if it be required to know what Force is ſufficient to navigate it in a Calm, for Example after the Rate of two Miles an Hour, we had need only to multiply 9.8, the Weight of Water againſt one Foot, by 500, the whole Surface of Reſiſtance, and the Product will be 4900 Pounds equal to the Force required; and if we would have it to ſail after the Rate of 3 Mile an Hour, it would require ſomewhat more than double the Force to effect it, as the Method of Calculation, here laid down, would ſhew.

And this Method of Calculation would undoubtedly obtain, if the Form of a Ship was an exact Parallelopepid, at each End flat and ſquare; but the Figure and Shape of it is ſo artfully contrived to facilitate its Paſſage thro' the Water, that it very much alters the Caſe, as the Experiment underneath will demonſtrate.

Art. 11. It is a Propoſition ſelf-evident, *That a Force or Power, whatſoever it be, that is ſufficient to hold a Boat or Veſſel againſt a Current of a known Velocity, the ſame Force or Power would draw it with an equal Degree of Velocity in a ſtill Water*, I mean with the ſame Swiftneſs as ſuch a Current runs at. In conſequence of this Propoſition I made the following Experiment.

Art. 12. In the River *Parret* at *Bridgwater*, I procured a ſmall Veſſel about 50 Ton, whoſe croſs Section at the main Breadth was 15 Foot, and being about 3 fourths loaden, it ſunk to the Depth of 6 Foot and a half, or drew ſo much Water, as 'tis called, not including the Keel, ſo that the Surface of Reſiſtance might be about 85 Foot. From a Cable faſten'd croſs the River, in the Middle of it we had a Line fixed; at the Diſtance of about 20 or 30 Yards from the Cable was the Veſſel with a Block laſhed to the middle part of the Bowſprit, over this Block was brought the Line, to which was faſten'd a Scale to receive ſuch Weight, as we ſhould want from a Boat attending underneath to make a Counterpoiſe againſt the Stream. Soon after the Tide began to ebb we tried the Experiment, what Weight it would bear, and found it to be hardly half a hundred; after a while we added more Weight, as the Tide of ebb ran ſtronger, and at length it ſuſtained 325 Pound *Averdupoize*, Weights, Scale and all. At the ſame time when the Current was at that Strength, we threw into the River a roundiſh Block of Deal Timber, which we had prepared for the Purpoſe, about 6 or 7 Inches Diameter, and 10 Inches long, with a ſufficient Quantity of Lead nailed to the Bottom of it to make it ſwim upright, about 2 Inches of it appearing above Water; and at the

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ſame time we alſo threw in an old Hoop about a Foot and a half Diameter, for half a Mile or more they kept Pace pretty well together, after that the Block happening to come near the Shore, its Motion was retarded, and at length it lodged on the Side of the Bank; but the Hoop all the while went on in very good Order, and we attended it whilſt it floated along a full meaſured Mile, which it did in 26 Minutes, as we obſerved by our Watches: So that the Current ran at the rate of a Mile in 26 Minutes, or 2 Mile and 3 tenths in an Hour.

Art. 13. This Experiment was made with great Care and pretty good Exactneſs, ſo that we may adventure to deduce Rules for Calculation from it. The firſt fundamental Propoſition will ſtand inconteſtibly thus; *That the Force Weight or Power of* 325 *Pound will navigate a Ship, whoſe Surface of Reſiſtance contains* 85 *ſquare Feet, at the rate of* 1 *Mile in* 26 *Minutes, or* 2 *Mile and* 3 *tenths in an Hour.* However, that a ſufficient Allowance may be made for the Friction of the Block, the Stiffneſs of the Rope, *&c.* we will ſuppoſe, that the Ship would have ſuſpended 15 Pound more, *viz.* in all 340 Pound, which 340 Pound being divided by 85, the ſuperficial ſquare Feet in the Ship's Section, the Quotient will be 4 Pound to each Foot: Then as the Square of the Velocity of 2.3 Miles an Hour is to the Square of the Velocity of 2 Miles an Hour, ſo is 4 Pound to a fourth proportional, which by working will be found to be 3 Pound, and a trifle more, which is inconſiderable, after the great Allowance juſt now mentioned. Therefore 3 Pound to the Foot will be amply ſufficient to navigate a Ship after the rate of 2 Miles an Hour, and conſequently be admitted as a ſtanding Rule for all future Calculations.

Thus much may ſuffice for an Enquiry, what Force and Power is neceſſarily required to navigate a Ship in a Calm, which I have deduced, partly from the Speculation of rowing the Galleys, and from other Mens Writings and Obſervations; but chiefly from ſeveral of mine own Experiments; by which, I apprehend, I am come to a great Degree of Certainty.

In the next Place then I am to explain my own Method, which, as I have hinted above, is by forcing Water, or ſome other Fluid, through the Stern or hinder Part of the Ship into the Sea, by a proper Engine or Engines placed within the Ship for that Purpoſe. The other Fluids beſides Water that I am to make Uſe of for this Purpoſe, are Air and Fire, as I have declared in the Specification of my Patent.

ART. 14. I got a Sort of Force Pump fitted in thro' the Bottom of a large Cock-Boat, with a Valve on the lower End of it opening upwards, ſo as to let in the Water into the Pump-Barrel from under the Boat, and prevent its Return that Way; a little higher up was a Spout about 3 Foot long fixed into the Barrel of the Pump horizontally, and the End of it went thro' the Stern of the Boat, about half a Foot under Water; the Barrel of the Pump was about 5 Inches

Diameter, and the Bore of the Spout, where it delivered the Water, ſomewhat leſs than 2 Inches. Things being thus prepared, and the Boat in a Mill-pond River, where there was no Current, the Pump was ſet to work, and it moved on the Boat after the Rate of about a Mile and half an Hour. The Boat was loaded, ſo as to ſink to a Depth, a Section of which I computed to be equal to 4 ſquare Feet; the Weight upon each Foot, after the Rate of a Mile and half an Hour, is one Pound and 6875 in Decimals, or 6 Pound three quarters on the 4 Foot, the Double of which is 13 Pound and a half, (the Reaſon for doubling it will be ſeen hereafter) which, beſides the Friction of the Force Pump (which was not a very good one) was all the Force required to give it a Motion of half a League an Hour.

Some preliminary Suppoſitions in order for a Deſcription of a Pneumatick Engine to navigate a Seventy Gun Ship in a Calm.

Art. 15. In the firſt Place, let there be ſuppoſed to be prepared two large Cheſts which may be called the Air Cheſts, of thick Deal Plank 12 Foot ſquare, and about 7 or 8 Foot deep, made to the greateſt Truth and Exactneſs, and the Joints all tight and well ſecured, or they may be made of a cylindrical Figure. Theſe are to be ſuppoſed to be ſet Side by Side in ſome convenient Place, towards the Stern of the Ship, at ſuch an Height, that their Bottoms may be about 7 or 8 Foot under the Water-Mark. Each of theſe Air-Cheſts is to have a Piſton fitted to it, and leather'd all round in a good Workman-like Manner. Theſe Piſtons are to be furniſhed each of 'em with 3 or 4 Braſs Valves two Foot diameter, opening into the Cavity of the Cheſts, and to be provided with Springs to ſhut them, as Occaſion ſhall require.

Art. 16. Before I deſcribe the Method of working theſe Piſtons, it may not be amiſs to take a Survey of the Power and Effect they would have to move a Ship, according to the known Laws of Motion and Rules of mechanical Operations, for the preſent taking it for granted, that we can find an adequate Power to work ſuch an Engine. This is a matter of great Importance, and will deſerve to be examined with the utmoſt Strictneſs and Impartiality; for if I am miſtaken herein, I muſt own it a fundamental Error, and I muſt come infinitely ſhort of what I pretend to. And firſt perhaps it will be objected, that Air being ſo light a Body, ſo tenuious and yielding, as alſo ſo compreſſible and elaſtick, I ſhall be able to make little or no Impreſſion with it againſt the Water, which is a Fluid of ſo ſuperior a Gravity and Denſity. This indeed looks like an Objection to vulgar Apprehenſions; but I hope for better Quarter from the Learned and ſkilful in Mechanicks; they will agree with me, that an Impulſe made on a Body of Air in a confined Place will communicate the ſame Degree of Motion to any other Body, whether fluid or ſolid, by a Shove it will give it, a ſmall Allowance only being made on account of its Compreſſibility, which is not to be look'd upon to be very great neither: For in the Caſe before us, in a Column of Air 12 Foot ſquare, it would require more than 30000 Pound Weight to compreſs the Column, ſo as to ſhorten it 3 Inches; therefore, when a great Weight or Force comes upon it, it will not be ſqueezed together, but it muſt go *quà data porta*, with a Celerity correſpondent to the Weight incumbent, or Force, from whence it receives the Impulſe, and the Diameters of the *Foramen* or *Foramina*, where it makes its Eſcape.

ART. 17. If ſuch a Column of Air as we are ſpeaking of 12 Foot ſquare was ſuppoſed to be carried out againſt the Sea Water horizontally in its full Dimenſions at the Stern of the Ship; ſuppoſing, I ſay, the Make of a Ship would admit of ſuch a Thing, in ſuch caſe the Shove or Impulſe the Air would make againſt the Water would be equal to the Impreſſion it received at the Top of the Column by the Piſton; this granted, we will ſuppoſe farther the Velocity of the Motion of the Piſton to be 2 Yards in 2 Seconds in each Cheſt, which, added together, would make as it were a continued Stream of Air iſſuing out with the Celerity of 2 Yards in every Second of Time, which is more than 4 Miles an Hour, equal in Weight to 1728 Pound and upwards. Now the Reſiſtances of

Fluids to Bodies moving in them being as the Squares of their Velocities, half this Power will be expended in ſhoving the Ship forward, or (which is the ſame Thing) in making its Effort againſt the Water afore the Ship; and the other half in ſhoving back or ſpurning againſt the Water behind the Ship. We may juſtly enough compare it to the Exploſion of Gunpowder in the Barrel of a Cannon, half of whoſe Force is employed in ſending forward the Ball, and the other half in making the Cannon to recoil; tho' it be not exactly ſo, it matters not, it ſerves to illuſtrate the Notion; or it is like driving a Wedge, which preſſes as much on one Side of the Block to be cloven, where the Crack or Cleaving is, as on the other. According to this Computation, the Ship would have the Weight of 864 Pound impreſſed on it to forward its Motion, which in a 70 Gun Ship, whoſe Surface of Reſiſtance is 500 ſquare Feet, being divided by that Sum, the Quotient will be one Pound .72 *&c.* in Decimals on each Foot, ſufficient to navigate ſuch a Ship more than half a League an Hour; and would require no more than 70 Men to work it, (was it poſſible to do it in this manner) as will appear hereafter. Thus far Things are plain, and we are involved in no Obſcurity.

ART. 18. To render this Engine practicable for Navigation, it is neceſſary that the Conveyances of the Air thro' the Stern of the Ship into the Sea be leſſened, and it would be expedient to have the Air-Cheſts alſo, ſo, as much as conveniently may be, diminiſhed, that they may not be too cumberſome in the Ship. It is viſible, that every where I entirely depend on the Truth of the Propoſition, *That the Reſiſtances of Fluids are as the Squares of the Velocities.* I am not ignorant however, that it has been diſputed; but believe, tho' I am not Maſter enough of the Mathematicks to demonſtrate it, that it will be allow'd me, that it is extreamly near ſo, and near enough for Practice, which is all I contend for. If the Air-Cheſts, or Cylinders, if they be made round, or Pump-Barrels, let 'em be called what any one pleaſes, be made no more than 7 Foot Diameter, with Piſtons fitted to them, and their Trunks or Tubes to convey the Air into the Sea 2 Foot ſquare, and the Strokes be made as before obſerved; then will the Stream iſſuing from them move with a Velocity of 48 Miles an Hour, operating upon a Volume of Water 2 Foot ſquare, or of 4 ſquare Feet; the Effect of it will be, that it will impreſs a Force of 6912 Pound, which being divided by 500, the ſquare Feet of Reſiſtance in a 70 Gun Ship, the Quotient will be 13 Pound and eight tenths on every Foot, which being halved is 6.9, more than ſufficient to navigate ſuch a Ship after the Rate of 3 Mile an Hour, and the Number of Men for that Work would be 276. If the Square of the Air-Cheſts be leſſen'd to 5 Foot, and the Tubes to convey the Air into the Sea to 18 Inches, then will the Stream iſſuing from them move with a Velocity 44 Miles an Hour, operating upon a Volume of Water 18 Inches ſquare, or of 2 ſquare Feet and a quarter, and the Effect will be, that it will impreſs a Force of 1452 Pound, which being divided, as above, by 500, the Quotient will be 2 Pound and 9 tenths, which being halved is 1.45, within a trifle enough to navigate ſuch a Ship after the rate of half a League an Hour, and will require no more than 58 Men. Theſe two Examples may be ſufficient, ſince there is an infinite Variety, which any one may try at Pleaſure.

The Deſcription of a Water Engine to navigate a ſmall Ship, for Example, about 200 *Ton. Such a Veſſel at the main Beam may meaſure about* 22 *Foot, and may draw about* 11 *Foot Water, not including the Keel.*

ART. 19. For the accompliſhing this Deſign, a little Portion of the Ship abaſt muſt be divided off by a very ſtrong and firm Partition, ſuch as may be Proof againſt the Sea. Into this Room, as I may call it, the Water may be permitted to come in the Intervals of the Strokes of the Piſton, thro' ſeveral Inlets or Openings from the Bottom of the Ship by Valves opening inwards; ſo that the Water may come as high in that Room, as it is in the Sea without ſide the Ship. In this Room is to be placed a Cylinder or a Tube of 6 Foot ſquare, and about 7 Foot long, open at the Bottom, with a Piſton fitted to it. The whole Room muſt be cloſely ſealed down with good ſtrong Planks every where, except over the Opening of the Tube, where the Piſton works. When the Piſton works, it forces the Water in the Room into the Sea thro' 2 Tubes, each a little more than a Foot ſquare, one on each Side of the Stern-poſt opening into the Sea, where they are to deliver their Water; theſe are to be placed in a level Line parallel with the Keel, and are to be of a convenient Length, they are not to be contiguous to the Cylinder, or Pump-Barrel. The Strokes here being but once in 2 Seconds, the Piſton moves 3 Foot in a Second, which is ſomewhat more than 2 Mile an Hour, the Water will iſſue out thro' the Tubes into the Sea after the rate of 16 Mile an Hour, operating upon a Volume of Water 18 Inches ſquare, or of 2 ſquare Feet and a quarter, and the Effect will be, that it will impreſs a Force equal to 786 Pound Weight, which being divided by 200, the ſquare Feet of Reſiſtance, the Quotient will be 3 Pound and 9 Tenths, which being halved, is 1.95 Pound upon each Foot, which is almoſt enough to navigate the Ship after the rate of a Mile and 3 Fourths an Hour, and requires about 15 or 16 Men to do it by Hand. This alſo may be varied according to the Bigneſs of the Ship, and other Circumſtances *pro re nata*.

ART. 20. Having proceeded thus far in an untrodden Path, it will be now incumbent upon me to ſhew in what Manner the Engines are to be wrought, how and by what Powers and Force the Piſtons are to be moved, in order to communicate a Motion to the Ship, *&c.* The Powers to be made uſe of are either the Strength of Men, or the Application of the Fire-Engine,

gine, and, upon ſome very extraordinary Occaſions, the Exploſion of Gun-powder. The Manner of working the Piſtons is to be by Wheels and Chains, which is the very beſt Way of all, being the moſt ſimple, and liable to the leaſt Friction of any. Firſt then for doing it by Hand. The Stroke of the Piſton, as has been noted above, being to be about 6 Foot, and the Reach of a Man, as he is to ſit in a rowing Poſture, being not much more than 3 Foot, the *Radius*, that moves the Piſton, muſt be double to that by which the Men pull at. A very few Men can work the Piſton in any Ship, but then if they are few, the Strokes will not be quick enough, and the Motion of the Ship very ſlow; the more Hands are employ'd, the quicker the Strokes will be, and the Ship will receive the greater Impulſe. The Men may be ranged along between Decks at a great Length, and may work it by means of a long Pole, with ſmall croſs Bars or Handles to pull by, as will be found moſt commodious for the Purpoſe. There are two Piſtons in the pneumatick Engine to be wrought alternately, of which Mention was made above. This is effected by ſeating one half of the Men with their Faces towards the Prow, and the other half towards the Stern, and the making uſe of two Wheels or Sectors of Circles, which is explained in the Draught, *Fig*. 3. but could be made much more intelligible by a Model, than by any Draught or Scheme. The Strokes of the Piſtons are alternate, as I have ſaid, ſo that between the two they create a perpetual Stream, inceſſantly pouring forth from 10 to 150 Miles an Hour, if one pleaſes (let it not be thought incredible, when Mr. *Newſham*'s Engine ſpouts Water after the rate of upwards of 230 Miles an Hour, as any one, who will be at the pains to calculate, may find; and a Bullet out of a Cannon moves after the rate of above 430 Mile an Hour.) The Reſiſtance of the Sea Water againſt ſo very rapid a Stream, eſpecially becauſe it is thrown out at ſuch a Diſtance under the Surface, is very conſiderable, as may be calculated by the Rules laid down; and tho' it preſſes upon but a ſmall Volume of Water, yet by its prodigious Celerity an ample Amends is made, as it is eaſy to compute, and will be made good in Experience. *N.B.* A 70 Gun Ship may be about 1000 Ton, carrying about 430 Men.

The Manner of applying the Engine for raiſing Water by Fire to navigate a Ship in a Calm.

Art. 21. I muſt ſuppoſe my Reader to underſtand the Conſtruction and Method of working of Engines to raiſe Water by the impellent Force of Fire, as now in Practice at *York-Buildings*, and at ſeveral other Places in *England* for draining Mines: He muſt alſo attend to the Alteration, I have propoſed to make in it, *Diſſert.* I. *Art.* 5, &c. for when it is modelled after the Manner there propoſed, it may be put on Board, and made uſe of to navigate a Ship; but then the Steam-Barrel muſt be ſet down almoſt upon the Level with the Boiler, which may be done by means of a crooked Pipe of Conveyance for the Steam into the great Cylinder; for the Steam may be made to deſcend as well as aſcend into the Cylinder or Steam-Barrel. If it was not contrived after this Manner, the Leaver or Beam would riſe too high in the Ship above the Deck. This Inconvenience being thus prevented, let us ſuppoſe a Fire-Engine with its Furniture (tho' it is not needful, that it be made to work itſelf, ſince 4 or 5 Men, there being enough in the Ship, can ſupply it by Hand) to be placed in a 70 Gun Ship, having on board the pneumatick Engine above deſcribed, with two 7 Foot Cylinders, and their Piſtons accordingly fitted, *&c.* Only here it is to be obſerved, that the two Piſtons are to be made ſo as to ſtrike together, the Fire-Engine being powerful enough to work both of them at once. The Engine, as it is well known, ſtrikes about 12 Strokes in a Minute, one every 5 Seconds, which Stroke in the large Engine is computed at about 5 Ton, ſo that an Impulſe of a Weight equal to one Ton every Second is communicated, half of which goes towards forwarding the Ship (as has been before obſerved) that half therefore equal to 1000 Weight being divided by 500, the Feet of Reſiſtance gives in the Quote 2 Pound, which is almoſt ſufficient to navigate ſuch a Ship after the rate of 1 Mile in 3 quarters of an Hour, which, if done by Hand, would require between 90 and 100 Men; ſo that the Engine performs the Work of ſuch a Number of Hands. The Fire-Engine is capable of being well adapted for this Purpoſe, becauſe it ſtrikes a Stroke of 6 or 7 Foot in Length. And I am perſuaded, that it will perform to a greater Degree, than what I here have mention'd, on account of the prodigious Celerity of its Strokes, although they do not follow one another ſo quick, as one could wiſh: Inſomuch, that I think there is no manner of Doubt, that if a Couple of 'em were apply'd to a Ship of 12 or 14 hundred Ton, they would impel it at the rate of three Knots an Hour.

Art. 22. It remains now that I ſhould give ſome Account of what Helps are to be had from the Exploſion of Gunpowder for the giving Motion to a Ship on ſome extraordinary Occaſions, as in Sea-Engagements, in great Dangers of Shipwreck, or the like: But this is a Thing of ſuch a Nature and Conſequence, that it muſt not be publiſhed to the World over-haſtily, without mature Deliberation, as well as great Caution; for I have had ſome Doubtings with myſelf, whether ſome bad Uſes might not be made of it, to the great Detriment and Prejudice of Mankind. Moreover, there are alſo ſome other Engines, beſides what relate to Shipping, which, to their great Improvement, may be brought to receive Motion from this ſame powerful Agent. Wherefore, upon the preſent View of Things, I cannot judge it to be ſo convenient at the preſent to unfold this great Myſtery of the Uſe of Gunpowder in theſe Reſpects, and to explain the Methods of applying it to the various Purpoſes it is capable of; but rather chooſe to reſerve it for a future Treatiſe, if it ſhall pleaſe God to grant me Life and Health to go on with my Experiments, and to perfect my Speculations in that Affair, wherein, when I am upon the Subject of Gunpowder, I ſhall explain a new Invention of a Piece of Ordnance about 4 Foot and a half long, conſiſting but of half the Weight of Metal of a common Cannon, and requiring no more than one ſixth Part of Gunpowder for the Charge, yet will do the ſame Execution with the other. It is obvious enough at the firſt Hearing, how advantageous Guns of this Make would be on Shipboard, and how commodious and portable by Land.

Art. 23. Now I am diſcourſing on Maritime Affairs, I hope my kind Reader will be ſo good to indulge me a little, whilſt I juſt mention the Circumſtances of an Invention (I am in ſome meaſure entitled unto) which, I believe, has not unto this Day received its full Improvement. In the Year 1716, the laſt Day of *May*, I communicated to the Royal Society an Invention of mine, which I called the *Perpetual Log*, or *Marine Hodometer*, ſhewing the Way of a Ship by Inſpection, by an Index on a Dial-plate. A Model of which Invention was produced, and an Account of its Uſe in Writing delivered at the ſame Time; and received with an Approbation of it in Theory by the ſaid honourable Society; and the Model laid up in their Repoſitory, and the Writing committed to their Regiſter, &c. Soon after this, upon Application made to the Admiralty, an Order was given by the Commiſſioners for its being tried at Sea, and in Order thereunto the Machine was performed from the aforeſaid Model by the famous Mr. *Rowley*, and was put on Board Capt. *Chandler*, who ſailed for the *Weſt-Indies*, but he dying in the Voyage, I never heard any Thing more of the Experiment, until 2 or 3 Years after; when I was informed, that one Mr. *Henry de Saumarez*, a *Guernſey* Man, was reviving it, under the Title of *the Marine Surveyor*; and indeed, as may be ſeen by the ſeveral Accounts printed in the Tranſactions of the Royal Society, he had taken a great deal of Pains in the Thing, and perhaps in ſome degree improved the firſt Contrivance, and I heartily wiſh he had lived to have brought it to it to its greateſt Perfection; all that I claim in it is the Invention of it at firſt. At the ſame Time I acquainted the Admiralty, or at leaſt ſome of the honourable Commiſſioners, that I knew of a Method of finding the Influence of Currents, and Lee-way of the Ship, without ſtirring out of it; but I do not underſtand, that now after 14 Years, any Body has as yet hit of that Notion. After ſo many Pretences, there have been offered to the World to ſecure Ships from the Worm in the *Weſt-Indies*, perhaps it would be eſteemed a very great Preſumption in me, who am of a very obſcure Character, ſhould I ſay, I can ſo prepare Plank for the building of Ships, at a very ſmall Expence, that the Worm will never touch it: but this at the preſent I mention here only as a Problem.

DISSERTATION III.

A new Method of drying Malt, in ſuch a manner that no Smoak of the Fuel affects it; and the Beer brew'd therewith is render'd more wholeſome and pleaſant.

ART. I. IN the common Way of drying Malt, the groſs Fumes or *Halitus* of the Fire paſs through the Malt to exhale the Humidity of it; theſe Fumes communicate an ill ſmoaky Taſte to the Malt, different according to the Nature of the Fuel made Uſe of in the drying. Hence it is, that the Drinkers of Beer brew'd with Coal-dry'd Malt condemn the Wood or Straw-dry'd, alledging it has a ſmoaky Taſte, gives them the Heart-burning, *&c.* The Drinkers of the Wood or Straw-dry'd ſay the ſame of the Coal-dry'd; and indeed both of them affirm it with great Truth, only Uſe and Cuſtom in the Drinkers of each Sort have familiarized the Flavour of one and the other to themſelves; whereas in Reality all Sorts of it have a ſmoaky Taſte, more or leſs according to the Kind and Nature of the Fuel wherewith it is dried.

ART. 2. To remedy this Inconvenience, and to render Malt Drink the more pleaſant and wholeſome, I have diſcover'd a new Method of drying Malt with any

Sort of Fuel whatſoever, after ſuch a Manner, that no Smoak at all comes at the Malt.

This is to be done in a very eaſy, ſimple and natural Way, *viz.* By laying the Malt to dry on a *Stratum* of boiling Water, included in a thin flat Boiler, artfully placed in a proper Kiln for that Purpoſe; ſo that by the Intervention of the Water between the Fire and the Malt, the Malt is dry'd in a very gentle and uniform manner, without Danger of being burnt or ſmoak'd.

Art. 3. The Experiment I at firſt try'd, was as follows; I caus'd a Tin Veſſel to be made, about 10 Inches Diameter, and 8 or 9 Inches deep, with a double Bottom, as in the Figure ABCD, Fig. 4. The Cavity between the two Bottoms being about 2 Inches deep was fill'd with Water at the Top of the Pipe D, about 2 Inches Diameter; and the Veſſel being placed on a ſmall Fire of Wood Coals, the Water was ſoon made to boil and bubble up at the Pipe D; and a very ſmall Fire would keep it boiling. Then the Malt was laid in the Cavity above on the upper Bottom to dry, and being laid on 3 Inches thick, it was 12 Hours in drying, and at 4 Inches thick it required 18 Hours. With Malt dried in this manner I brew'd ſome Beer, which was of a fine delicious Flavour, without the leaſt ſmoaky Taſte.

Art. 4. For the Purpoſe then; in order to dry large Quantities of Malt in this Way, a Kiln may be prepared, as I projected it more than a Year and half ſince (and ſhould have built it if ſome very great Misfortune had not happen'd in my Family) after the following manner; ſee Fig. 5. firſt a large Copper, Braſs or Iron Bottom muſt be made, ſuppoſe about 6 Foot broad, and 20 or 25 Foot in Length, or more, according to the Largeneſs of the Kiln intended, the Sides to be turn'd up about 4 or 5 Inches, in order to have a Floor of Tin Plates well ſolder'd together placed all over it, at about 3 Inches Diſtance above the Copper Bottom; which Floor of Tin Plates may be ſupported from the ſaid Copper-Bottom with thin Strips of Wood, or the like Contrivance; this Veſſel, thus fitly compacted together, I call the Boiler, which may conveniently enough perhaps be made all of Iron both Top and Bottom, as the Salt-Pans are made, or the upper Side, where the Malt is to be laid on, may be made of Lead, if Lead will not be thought to communicate an Unwholſomneſs to the Malt. This Boiler muſt be ſet in a Kiln of Brick-work made to receive it, and the Bottom of it to be 6 or 8 Inches above the Brick Floor. The End where the Fire is to be made, muſt be laid about 2 Foot lower than the upper End, where the Flues are to carry off the Smoak of the Fire, and Fumes of the Water.

Art. 5. The Boiler thus placed muſt be fill'd with Water at the upper End, where it muſt be turn'd up about a Foot high, and left open for diſcharging the Fumes occaſion'd by the boiling of the Water; and the Supply of Water to anſwer that Evaporation, may moſt commodiouſly be furniſh'd by a Pipe near the lower End over the Fire-place, where the Heat may be ſuppoſed to be the ſtrongeſt.

The Malt is to be laid on this Boiler about 4 Inches thick, which will contain (the Dimenſions being as before ſpoken) about 20 or 25 Buſhels. It muſt be turn'd pretty often, as is uſually done in other Ways of Drying; and it will be dry'd in about 18 Hours.

Art. 6. By all the Experiments I have been hitherto able to make, I do not find that this Method will take more Fuel, or require longer Time for the drying, than the common Way: And any ſort of Coals, Turff or Peat, Furze, Hearth, Straw, or any other combuſtible Matter whatſoever, that will but heat Water, may be uſed to as good Purpoſe as chared-Coals, or the fineſt and choiceſt cleft Wood.

FINIS.

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